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GENERAL DYNAMICS | CONVAIR

Report No. 8926-033

Material - Coatings And Finishes - Chemical Conversion Films

Corrosion Resistance, Electrical Conductivity And Adhesion Characteristics

A. F. Hooper, J. C. George, E. E. Keller

10 March 1960

Post Office Box 1950, San [illegible] 12, California CYpress 6-6611
Material Post Office Box 2071 BRoadway 3-8000 [illegible] Post Office Box 510

Report 8926-033

Material - Coatings and Finishes - Chemical Conversion Films

Corrosion Resistance, Electrical Conductivity and Adhesion Characteristics

Abstract

Twelve commercial chemical conversion coatings for aluminum, which conform with Mil-C-5541 requirements, were evaluated when applied to 2024-T3 clad and bare, and 7075-T6 clad and bare aluminum alloys. Salt spray, 100% relative humidity and atmospheric testing was done with coated, coated and lacquered, and galvanically coupled (Type 301 stainless steel) specimens. The electrical conductivity of the various coatings were determined by resistance measurement. Paint adhesion was determined by impact shock resistance methods. Wide variations were not found in the corrosion protection afforded by the several materials although Alodine* 600 offered a slight advantage. Appreciable reductions in the electrical conductivity of surfaces resulted from chemical conversion film application. These reductions tended to be specific with each aluminum alloy surface responding best to a specific proprietary coating. Impact shock tests with a wash prime-zinc chromate lacquer primer-lacquer topcoat paint system indicated better adhesion with Alodine* 1000 and Bonderite** 710 chemical films.

* American Chemical Paint Co.
** Parker Rust Proof Co.

Reference: Hooper, A. F., George, J. C., Keller, E. E., "Evaluation of Chemical Conversion Films for Aluminum Alloys," General Dynamics/Convair Report MP 59-194, San Diego, California, 10 March 1960. (Reference attached).

CONVAIR

A DIVISION OF GENERAL DYNAMICS CORPORATION

SAN DIEGO

STRUCTURES-MATERIALS LABORATORIES

REPORT IP-59-194

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TITLE

REPORT NO. IP-59-194

EVALUATION
OF
CHEMICAL CONVERSION FILMS
FOR
ALUMINUM ALLOYS

MODEL 7

CONTRACT NO. AF04(645)-4

PREPARED BY A. F. Hooper
A. F. Hooper

GROUP Materials & Processes Lab.

CHECKED BY J. C. Bourge
J. C. Bourge

REFERENCE

CHECKED BY C. C. Keller
C. C. Keller

APPROVED BY E. F. Strong
E. F. Strong, Chief of Structures & Materials Labs.

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APPROVED BY
W. P. Sutherland, Engr. Mgr.

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INTRODUCTION:

The surface treatment of aluminum alloys for corrosion protection and paint application is a major problem in the aircraft industry. Numerous chemical conversion films are available on the market, which meet the requirements of MIL-C-5541, "Chemical Films for Aluminum Alloys". Each company must select a product which will best suit their individual requirements. The requirements expressed were for a chemical conversion film which had good corrosion protection, electrical conductivity, and which provided a satisfactory surface for paint application.

OBJECT:

1. To evaluate the corrosion protection afforded by various chemical conversion films on clad and non-clad 2024-T3 and 7075-T6 aluminum alloys.

2. To determine the electrical resistance properties of the various chemical conversion films when applied on aluminum alloys.

3. To determine which chemical films provided the best surface for subsequent paint adhesion.

CONCLUSIONS:

1. There was not a wide variation in the corrosion protection afforded by the various chemical conversion films; however, Alodine 600, manufactured by American Chemical Paint Company, appeared to offer the best over-all protection.

2. Alodine 400, manufactured by American Chemical Paint Company, had the lowest electrical resistance of the chemical conversion films tested.

3. Impact shock tests indicated that the best paint adhesion was obtained over Alodine 1000 and Bonderite 710 chemical films.

TEST SPECIMENS & PROCEDURES:

A. Test Specimens

The test specimens were aluminum alloy panels which were given various surface treatments. The test specimens were fabricated using the following types of aluminum alloy.

1. 2024-T3 Clad
2. 2024-T3 Bare
3. 7075-T6 Clad
4. 7075-T6 Bare

One hundred twenty 0.032 x 3 x 10 inch panels and twelve 0.032 x 3 x 9 inch panels were cut from each of the above types of aluminum alloy. All panels of each of the four aluminum alloy types were cut from a single sheet of the aluminum alloy to reduce variables. The test specimens were divided equally into 12 groups of 44 panels per group. Each one of the groups was given one of the following 12 surface treatments.

TEST SPECIMENS & PROCEDURES:

A. Test Specimens (Continued)

1.	Alodine 600	-	1- 1.5 oz/gallon of water (MPS 71.06J)
2.	Alodine 400	-	0.2 gallons/gallon of water
3.	Alodine 1000	-	0.1 oz/gallon of water
4.	Turco 4354	-	1.5 oz/gallon of water
5.	Turco 4178	-	1.5oz of gallon of water
6.	Iridite 14-2	-	1.25 oz/gallon of water
7.	Iridite 14-9	-	0.2 oz/gallon of water
8.	Bonderite 710	-	0.5 pounds/gallon of water
9.	Oakite "Chromacoat"	-	3 oz/gallon of water
10.	Alodine 1200	-	1.0 oz/gallon of water
11.	Anodize per Mil-A-8625A		
12.	Control - No surface treatment		

A more detailed procedure for the application of the above surface treatments is presented in the Appendix of this report. All of the chemical conversion film treatments listed above were applied over Oakite #34 deoxidized surfaces.

One test set of 48-.032 x 3 x 10 inch specimens received the following hole pattern prior to surface treatment. Eight holes, 1/4" in size, were drilled in tandem in each panel at 1-1/4" spacing, maintaining a 1/2" edge distance. The same hole pattern was drilled at one edge of 48 - 0.040 x 10 x 10 inch -301 extra full hard stainless steel panels. These 48 panels of aluminum and stainless steel later comprised the bi-metallic couple specimens. The 48 bi-metallic test specimens were assembled, after surface treatment of the aluminum panels, with four cadmium plated steel bolts and washers with dry-film lubricant coated nuts in tandem. The other four fasteners were stainless steel bolts and washers with silver plated steel nuts.

Three sets of 48 panels, 0.032 x 3 x 10 inch in size, received the following finish system after receiving the individual surface treatments.

1. One spray coat of wash primer - MIL-C-8514
2. Two spray coats of zinc chromate primer MIL-P-8585
3. One spray coat of yellow lacquer - MIL-L-7178

The 12 surface treatments were applied to separate panels of the four types of aluminum alloys. These 48 test specimens comprised a test set for each of the test conditions.

TEST SPECIMENS & PROCEDURES:

B. Test Procedure

The above test specimens were tested using the following test exposure conditions:

1. 100% Relative Humidity - A test set of forty-eight unpainted test specimens was exposed to the humidity cabinet, operating in accordance with JAN-H-792, for 250 hours. The specimens were inspected during the test period every 24 hours, except for the weekend, for corrosion or other film failures.

2. Salt Spray Exposure Tests - The salt spray cabinet was operated in accordance with Federal Test Method Standard 151, Method 811.

Three different types of specimens were exposed to the salt spray cabinet.

a) Unpainted Specimens - A test set of forty-eight specimens was exposed to the salt spray cabinet for 168 hours. The lower half of the directly exposed surface of each specimen was cross-scribed through the protective surface treatment before exposure. The specimens were inspected every 24 hours during the test period, except on the weekend, for corrosion and film failure.

b) Painted Specimens - A test set of forty-eight painted specimens was exposed to the salt spray cabinet for 552 hours. A cross-scribe mark was made on the lower half of each specimen through the paint film and surface treatment to the metal substrate. Each specimen was inspected every 24 hours, except for weekends, for corrosion of the metal substrate or paint film failure.

c) Bi-Metallic Metal Couple Specimens - The forty-four unpainted bi-metallic couple specimens were exposed to the salt spray for 250 hours. The specimens were inspected every 24 hours, except for the weekend, for corrosion.

This test was conducted on all aluminum alloy and surface treatment combinations, except the four alodine 1200 surface treatment specimens which were introduced into the program after this test was completed.

3. Atmospheric Exposure Specimens - San Diego - A test set of forty-eight painted and unpainted specimens was exposed for ten months to industrial marine atmosphere in San Diego. The specimens were mounted in a rack at an angle of 45° from the vertical with southern exposure. The lower half of each specimen was cross-scribed to the metal substrate. The specimens were inspected periodically for corrosion, protective film and paint film failures.

TEST SPECIMENS & PROCEDURES:

D. 4. Electrical Resistance Tests - These tests were performed by Resistance, Capacitance and Inductance Section of the Astronautics Standards Laboratory. Two methods of measuring the electrical resistance were tried. The first method was found to be unsatisfactory, while the second method gave reproducible results. A statement from them giving the second test method is given below.

> "In this method the current and potential electrodes were separated. The current electrodes were solidly attached to the extreme ends of the panel. The potential electrodes, Leeds and Northrup knife edges making contact on one face of the panel only, were spaced 4 inches apart. Two measurements were made on one face, the panel was then turned over and two further measurements made, 4 measurements for each panel."

5. Impact Shock Resistance - Forty specimens, excluding the Alodine 1200 and control specimens, were subjected to an impact of a two-pound weight with a .05 inch diameter spherical head falling on the specimen through distances of from one to fifteen inches in one inch increments. (See Table VI) The impact was administered to apply a tension impact load on the paint film on the surface of the panel. The specimens were examined for cracking or scaling of the paint film as a result of the impact.

6. Accelerated Weathering Exposure - A test set of forty-eight specimens, 3 x 9 inch, was exposed in the Atlas, type XW Weatherometer, in accordance with Federal Test Method Standard No. 141, Method 6161, for 500 hours. The specimens were examined for corrosion or surface film failure periodically during the exposure period.

7. Tensile Testing - Tensile tests were conducted on the unpainted panels after subjection to salt spray and atmospheric exposure testing.

RESULTS:

The results of 100% relative humidity, salt spray-unpainted, salt spray-painted, atmospheric exposure, impact shock resistance and electrical resistance tests are shown in Tables II through VII, respectively. Table VIII shows the over-all total rating of the above tests conducted on the chemical conversion films.

The painted industrial marine atmospheric exposure test specimens showed no significant change, except general fading of the MIL-L-7178 yellow lacquer during ten months' exposure.

The bi-metallic stainless steel and aluminum alloy test specimens were severely corroded after 250 hours salt spray exposure. Significant differences in corrosion rate could be observed between aluminum alloys, but not between chemical conversion films applied on these aluminum alloys.

RESULTS: (Continued)

The accelerated weathering test specimens were all heavily water spotted during the 500 hours exposure in the Atlas, Type XW Weatherometer. Some of the more iridescent chemical conversion films showed some loss of color, but no significant corrosion.

The elongation results after tensile testing of unpainted atmospheric weathering and salt spray exposure specimens are shown in Figures 1 and 2.

DISCUSSION OF RESULTS:

The results of these tests show a very close correlation in the over-all corrosion protection afforded by the chemical conversion films under test. Visual inspections of the specimens exposed to the salt spray cabinet, humidity cabinet, and industrial marine atmosphere were used to evaluate the degree of corrosion protection afforded by each chemical conversion film. The results of such tests as bi-metallic stainless steel-aluminum alloy salt spray specimens, painted industrial marine atmospheric exposure specimens and accelerated weathering specimens, showed no significant difference in corrosion protection of the chemical conversion film for each test. Therefore, these tests were not used in the over-all evaluation of the corrosion protection afforded by each chemical conversion film. All of the chemical conversion films tested meet the requirements of MIL-C-5541, "Chemical Films for Aluminum Alloys" when applied using the process outlined by the manufacturer. The process outlined by each manufacturer was followed with the exception of the chemical cleaning process. All of the specimens,on which a chemical conversion film was applied, were solvent degreased and then cleaned with Oakite No. 34 deoxidizer. This chemical cleaner was used because of the availability of the bath and was agreeable by all manufacturers of the chemical conversion films under test.

The corrosion protection afforded by each chemical conversion film was evaluated according to its performance in the salt spray cabinet, humidity cabinet, and industrial marine atmospheric exposures. The chemical conversion films were evaluated in each test separately. The type of corrosion observed was recorded and each chemical conversion film was given an over-all rating for the test. A rating of 1 to 4 was given to each chemical conversion film, one being rated best. The over-all ratings for each test are recorded in Table VIII.

The total corrosion test values recorded in Table VIII show the final evaluation of corrosion performance of each chemical conversion film. This value was arrived at by a summation of the humidity, salt-spray and atmospheric exposure test over-all ratings. The over-all rating values of the salt spray and atmospheric exposure tests were doubled as they were thought to give more reliable indications of corrosion resistance than the humidity cabinet test.

Alodine 600, manufactured by American Chemical Paint Company, showed the best over-all corrosion protection of the chemical conversion films tested. (See Table VIII) Alodine 600 did not have as good an atmospheric exposure rating as Alodine 400 or Alodine 1000, but was superior after salt spray testing.

DISCUSSION OF RESULTS: (Continued)

The impact shock resistance test showed that the MIL-L-7178 lacquer finish system had better paint adhesion to Alodine 1000 and Bonderite 710 chemically treated aluminum alloy surfaces. (See Table VI)

The electrical resistance test results, shown in Table VII, indicate that Alodine 400 had the lowest electrical resistance. The resistance values obtained for all of the chemical conversion films and control specimens, except the anodized specimens, were between 66.99 and 91.18 micro-ohms. The resistance of the anodized surface film was extremely high and was not obtained for comparison. The resistance values shown above are the low and high values for all aluminum alloys. The resistance values obtained on each aluminum alloy show smaller differences in resistance. (See Table VII) The results of this test indicate that the electrical resistance value of the film should not be the basis for the selection of a particular chemical conversion film.

The percent elongation averages of three tensile specimens from each non-painted, 168-hour-salt spray exposure specimen, and each 10 month atmospheric exposure specimen, are presented in Figures 1 and 2. The percent elongation values presented are averages of only three tensile specimens, showing possible performance trends and not statistical averages of several specimens.

Bar graph plots of the percent elongation values show that in general 168 hours salt spray exposure is more severe than 10 months atmospheric exposure. This condition is most evident in the case of the bare 2024-T3 and bare 7075-T6 aluminum alloy specimens.

The superficial pitting of the clad 2024-T3 and clad 7075-T6 aluminum alloy specimens produced no significant reduction in percent elongation properties as determined by tensile tests.

NOTE: The data from which this report was prepared are recorded in Engineering Materials and Processes Laboratory Data Book #1002.

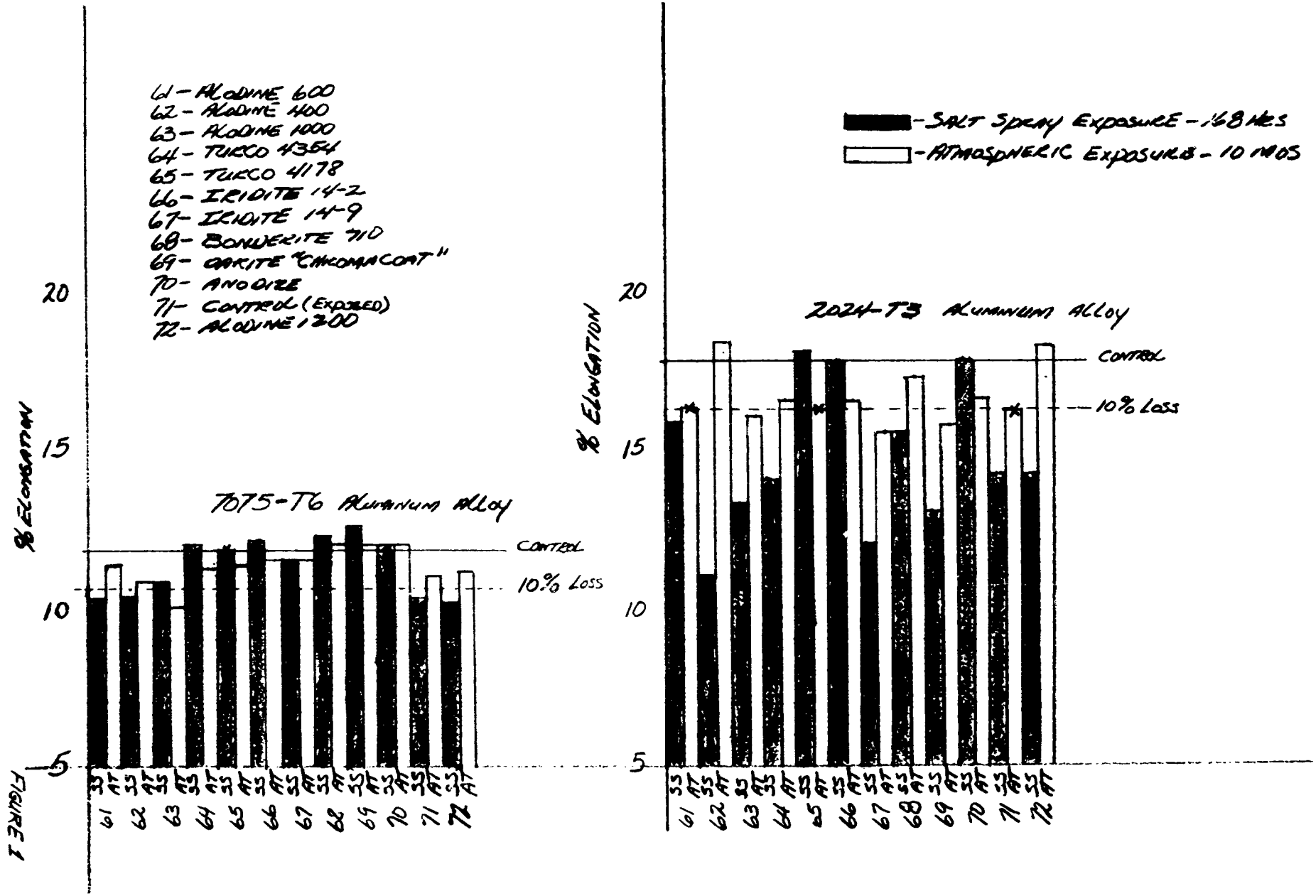
61 - ALODINE 600
62 - ALODINE 400
63 - ALODINE 1000
64 - TURCO 4364
65 - TURCO 4178
66 - IRIDITE 14-2
67 - IRIDITE 14-9
68 - BONDERITE 710
69 - OAKITE "CHROMACOAT"
70 - ANODIZE
71 - CONTROL (EXPOSED)
72 - ALODINE 1200
% ELONGATION
20
15
10
5
7075-T6 ALUMINUM ALLOY
CONTROL
10% LOSS
2024-T3 ALUMINUM ALLOY
SALT SPRAY EXPOSURE - 168 HRS
ATMOSPHERIC EXPOSURE - 10 MOS
SS AT
61 62 63 64 65 66 67 68 69 70 71 72

FIGURE 1

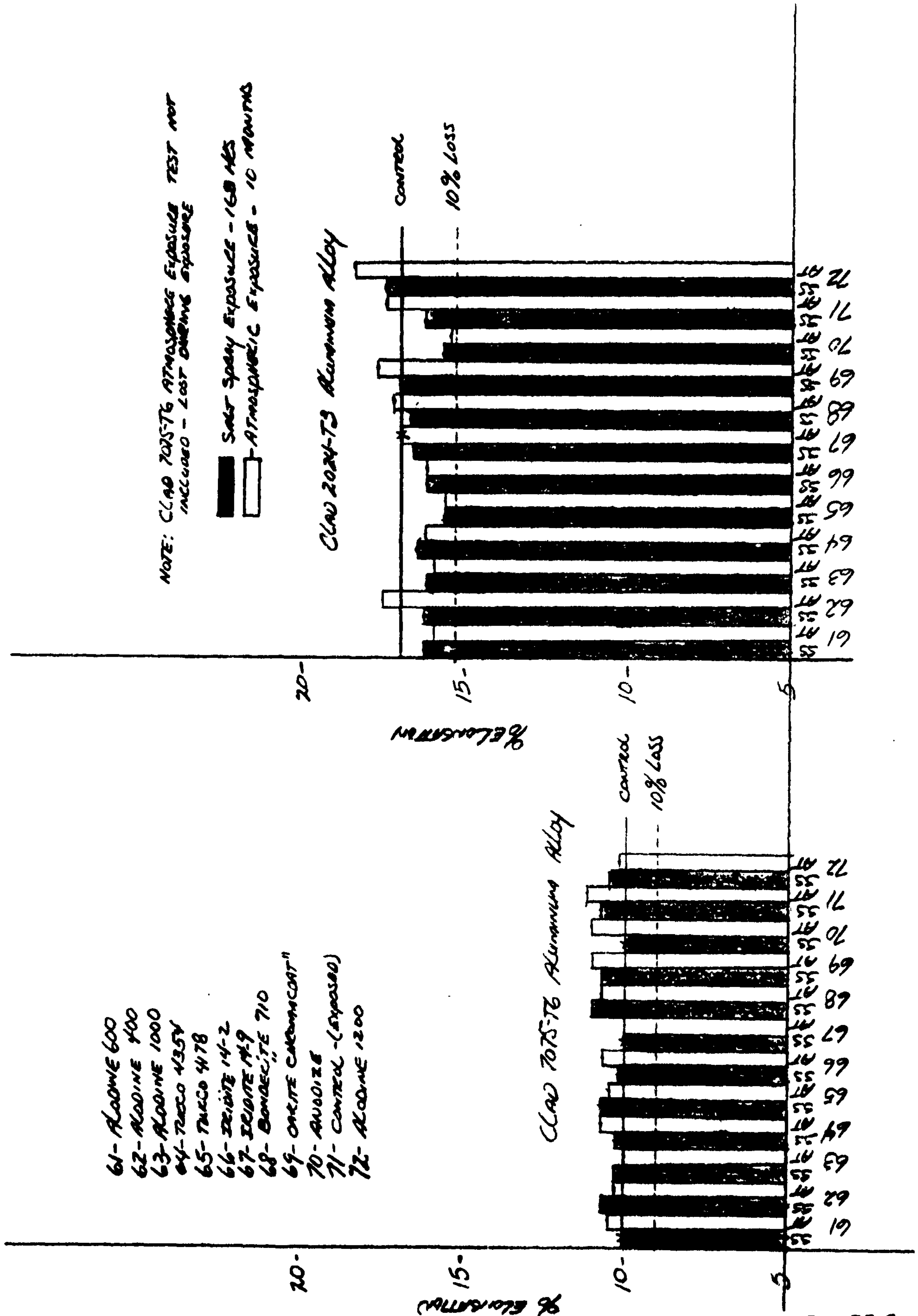
NOTE: CLAD 7075-T6 ATMOSPHERIC EXPOSURE TEST NOT INCLUDED - LOST DURING EXPOSURE
SALT SPRAY EXPOSURE - 168 HRS
ATMOSPHERIC EXPOSURE - 10 MONTHS
CLAD 2024-T3 ALUMINUM ALLOY
CLAD 7075-T6 ALUMINUM ALLOY
CONTROL
10% LOSS
% ELONGATION
20-
15-
10-
5
61- ALODINE 600
62- ALODINE 400
63- ALODINE 1000
64- TURCO 4354
65- TURCO 4178
66- IRIDITE 14-2
67- IRIDITE 14-9
68- BONDERITE 710
69- OAKITE "CHROMACOAT"
70- ANODIZE
71- CONTROL -(EXPOSED)
72- ALODINE 1200
SS
AT
61
62
63
64
65
66
67
68
69
70
71
72

FIGURE 2

TABLE I

CHEMICAL CONVERSION COATINGS & VENDOR SOURCE

Surface Treatment Identification	Chemical Conversion Coating	Vendor Source
1	Alodine 600	American Chemical Paint Co., Ambler, Pa.
2	Alodine 400	" " " " " "
3	Alodine 1000	" " " " " "
4	Turco 4354	Turco Products, Inc., Los Angeles, Calif.
5	Turco 4178	" " " " " "
6	Iridite 14-2	Allied Research Products, Inc., Baltimore, Md.
7	Iridite 14-9	" " " " " "
8	Bonderite 710	Parker Rust Proof Co., Detroit 11, Michigan
9	Oakite "Chromacoat"	Oakite Products, Inc., New York 6, N.Y.
10	Alodine 1200	American Chemical Paint Co., Ambler, Pa.
11	Anodize	Convair Plant #1 Production
12	Control - No Surface Treatment	

TABLE II

100% RELATIVE HUMIDITY CABINET TEST-250 HOURS

Surface Treatment Number	7075-T6	2024-T3	Clad 7075-T6	Clad 2024-T3	Over-All* Rating	Comment
1	1	1	1	1	1	No change observed.
2	3	4	1-2	1	3	Poor performance on bare aluminum alloys.
3	4	4	4	4	4	Heavy oxide film on all aluminum alloys.
4	3	2	1	1	2	Moderate Oxide film on bare aluminum alloys.
5	1	1	1	1	1	No change observed.
6	1	1	1	1	1	No change observed.
7	3-4	3-4	3	3	4	Moderate to heavy oxide film.
8	1-2	1-2	1-2	1	2	Slight change observed.
9	1	2-3	1	1	2	Slight change observed on 2024-T3 aluminum alloy.
10	1	1	1	1	1	No change observed.
11	4	4	3-4	3-4	4	Heavy oxide film on all aluminum alloys.
12	4	4	4	4	4	Heavy oxide film on all aluminum alloys.

*This rating of each chemical conversion film was based on the over-all performance of the coating of the aluminum alloys in the humidity cabinet.

1 - no change observed
2 - slight oxide film
3 - moderate oxide film
4 - heavy oxide film.

TABLE III

SALT SPRAY CABINET EXPOSURE - 168 HOURS

Surface Treatment Number	7075-T6	2024-T3	Clad 7075-T6	Clad 2024-T3	Over-All Rating 1-4 Group	Comments
1	1	1	2	1	1	Slight pitting on Clad 7075-T6.
2	4	3	4	3	4	Moderate to slight pitting on all aluminum alloys.
3	2	4	3	3	4	Slight to severe pitting.
4	2	2	2	2	2	Slight pitting on all aluminum alloys.
5	1	2	2	1	1	Slight pitting on 2024-T3 bare and clad 7075-T6.
6	1	2	2	2	2	Slight pitting on all aluminum alloys except 7075-T6 bare.
7	3	3	3	2	3	Slight to moderate pitting.
8	1	2	2	2	2	Slight pitting on all aluminum alloys except 7075-T6 bare
9	2	2	2	2	2	Slight pitting on all aluminum alloys.
10	2	2	3	1	2	Moderate pitting on Clad 7075-T6.
11	2	2	1	1	1	Slight pitting on bare 2024-T3 & 7075-T6.
12	4	4	3	2	4	Slight to severe pitting on the various aluminum alloys.

NOTE: 1 - no significant change
2- slight pitting
3 - moderate pitting
4 - severe pitting

TABLE IV

SALT SPRAY CABINET TEST - FINISHED PER 7-00004 - 552 HOURS

Surface Treatment Number	7075-T6	2024-T3	Clad 7075-T6	Clad 2024-T3	Overall Rating	Comments
1	2	2	3	2	1	
2	3	3	2	2	2	
3	2	2	3	2	1	
4	3	3	3	3	4	
5	2	3	3	3	3	
6	3	2	3	2	2	
7	3	2	3	2	2	
8	3	2	3	3	3	
9	3	2	3	2	2	
10	3	2	3	4	4	
11	2	3	3	2	2	
12	-	-	-	-	-	No test conducted.

The results of this test were very close.

TABLE V

INDUSTRIAL MARINE ATMOSPHERIC EXPOSURE TEST IN SAN DIEGO - 10 MONTHS

Surface Treatment Number	7075-T6	2024-T3	Clad 7075-T6	Clad 2024-T3	Overall Rating (1-4 Groups)	Comments
1	4	3	4	2	3	
2	1	3	1	1	1	
3	1	3	1	2	1	
4	1	3	4	2	2	
5	4	5	4	4	4	
6	3	3	5	7	4	
7	1	3	-	1	2	The clad 7075-T6 specimen was lost - given average rating.
8	1	1	4	4	2	
9	1	1	3	7	3	
10	5	5	5	4	4	
11	6	6	6	6	4	
12	1	4	2	2	2	

NOTE:
1 - slight small pits
2 - slight medium pits
3 - moderate small pits
4 - moderate medium pits
5 - heavy medium pits
6 - slight large pits
7 - moderate large pits

TABLE VI

IMPACT SHOCK TEST - ADHESION OF MIL-C-7178 FINISH SYSTEM TO THE VARIOUS SURFACE TREATMENTS ON ALUMINUM ALLOYS

Surface Treatment Number	7075-T6	2024-T3	Clad 7075-T6	Clad 2024-T3	Overall Rating (1-4 Groups)	Comments
1	5	3	4	3	4	
2	3	2	3	4	3	
3	2	1	1	3	1	
4	4	3	5	5	4	
5	3	2	5	2	3	
6	4	2	5	4	4	
7	2	4	5	5	4	
8	1	1	2	2	1	
9	2	2	3	3	2	
10	-	-	-	-	-	No test conducted over bare metal.
11	3	2	3	1	2	
12	-	-	-	-	-	Test complete at the time specimens were prepared.

NOTES:

(1) The MIL-C-7178 lacquer was applied over one coat of both MIL-C-8514 wash primer and MIL-P-8585 zinc chromate primer.

(2) The numerical value given each surface treatment on each aluminum alloy was based on visual inspection of the paint film failure on the specimen.

TABLE VII

ELECTRICAL RESISTANCE TEST RESULTS ON THE VARIOUS SURFACE TREATMENT FILMS

Surface Treatment Number	7075-T6 Micro-Ohms	2024-T3 Micro-Ohms	Clad 7075-T6 Micro-Ohms	Clad 2024-T3 Micro-Ohms	Over-All Rating
1	70.11	77.18	80.97	89.54	4
2	66.99	73.22	78.60	88.43	1
3	68.58	80.61	81.71	89.22	4
4	68.14	75.14	79.43	88.54	2
5	68.42	73.88	84.87	87.93	3
6	67.93	74.23	78.35	89.23	2
7	69.07	74.62	80.13	86.85	3
8	69.47	72.65	79.85	90.72	3
9	68.75	73.02	81.61	85.94	2
10	Specimens had not been prepared during the time of this test.				
11	An anodized surface has a very high resistance - no tests were conducted.				
12	69.54	78.85	80.45	91.18	4

TABLE VIII

TEST RESULTS - FINAL EVALUATION

Surface Treatment Number	Humidity (1X)	CORROSION TESTS				Impact Shock	Electrical Resistance
		Salt Spray Unpainted (2X)	Salt Spray Painted (2X)	Atmospheric Exposure (2X)	Corrosion Test Total		
1	1	1	1	3	11	4	4
2	3	4	2	1	17	3	1
3	4	4	1	1	16	1	4
4	2	2	4	2	18	4	2
5	1	1	3	4	17	3	3
6	1	2	2	4	17	4	2
7	4	3	2	2	18	4	3
8	2	2	3	2	16	1	3
9	2	2	2	3	16	2	2
10	1	2	4	4	21	-	-
11	4	1	2	4	18	2	-
12	4	4	-*	2	-	-	4

*No test was conducted.

NOTE: 1. The corrosion test total value was arrived at by doubling the salt spray and atmospheric exposure test values.

APPENDIX

1. Alodine 600 - This chemical conversion film was applied in Convair production using 1 - 1-1/2/oz/gallon in accordance with MPS 71.06J.

2. Alodine 400 -
   A. Solution - .0.25 oz Alodine #40/gallon;
      0.2 gallon Alodine #400 /gallon;
      Balance water
      Add - 0.25 oz Alodine #40 to 1/2 gallon water, heat to 100°F, add 0.2 gallon Alodine #400 and balance of water.

   B. Procedure of Application

      1. Solvent clean aluminum alloy panels - MEK
      2. Alkaline clean Oakite 61A - 10 minutes
      3. Rinse water
      4. Chemical clean - Oakite #34 - 5-10 minutes
      5. Rinse water
      6. Alodine #400 (100°F) 1-2 minutes
      7. Rinse water
      8. Rinse - addidated rinse (room temp.) alodine 1000 solution (alodine 1000 x 1:9)
      9. Oven Dry - 125°F 10-15 minutes

3. Alodine 1000
   A. Solution - 0.1 oz Alodine 1000/gallon of water - pH - 3.8

   B. Procedure for Application

      1. Solvent clean - Aluminum alloy panels - MEK
      2. Alkaline clean - Oakite #61A - 10 minutes
      3. Rinse water
      4. Chemical clean - Oakite #34 - 5-10 minutes
      5. Rinse water
      6. Alodine 1000 - 5 minutes (room temperature)
      7. Rinse water
      8. Oven dry - 125°F - 10-15 minutes

4. Turco 4358
   A. Solution - 1-1/2 oz Turco 4354/gallon water
      adjust pH to 2.4 to 2.6 using Ammonia, bath aged 24 hours

   B. Procedure for Application

      1. Solvent clean aluminum alloy panel - MEK
      2. Alkaline clean Oakite #61A - 10 minutes
      3. Rinse water
      4. Chemical clean - Oakite #34 5-10 minutes
      5. Rinse water
      6. Turco 4358 - 5 to 7 minutes @ 75° to 85°F
      7. Rinse water
      8. Oven dry - 125°F - 10-15 minutes

APPENDIX (Continued)

5. Turco 4178
   A. Solution - 1/2 oz of 42 Be° Nitric acid/gallon water
      Add slowly with stirring 1-1/2 oz of Turco 4178; adjust pH to 1.5 - 1.9 with Nitric Acid. Age bath 24 hours.

   B. Procedure for Application

      1. Solvent clean aluminum alloy panels - MEK
      2. Alkaline clean - Oakite #61A - 10 minutes
      3. Rinse water
      4. Chemical clean - Oakite #34 - 5-10 minutes
      5. Rinse water
      6. Turco 4178 - 3 to 5 minutes 75 to 85°F
      7. Rinse water
      8. Oven dry - 125°F - 10-15 minutes

6. Iridite 14-2
   A. Solution - 1-1/4 oz of Iridite 14-2/gallon water pH 1.5

   B. Procedure for Application

      1. Solvent clean aluminum alloy panels - MEK
      2. Alkaline clean - Oakite #61A - 10 minutes
      3. Rinse water
      4. Chemical clean - Oakite #34 - 5-10 minutes
      5. Rinse water
      6. Iridite 14-2 - 6 minutes at room temperature
      7. Rinse water
      8. Oven dry - 125°F - 10-15 minutes

7. Iridite 14-9
   A. Solution - 0.2 oz Iridite 14-9/gallon water pH - 2.3

   B. Procedure for Application

      1. Solvent cleaning aluminum alloy panels - MEK
      2. Alkaline cleaning - Oakite #61A - 10 minutes
      3. Rinse water
      4. Chemical clean - Oakite #34 - 5-10 minutes
      5. Rinse water
      6. Iridite 14-9 - 6 minutes
      7. Cold water rinse
      8. Hot water rinse 120°F - 30 seconds
      9. Oven dry - 125°F - 10-15 minutes

8. Bonderite 710
   A. Solution - 0.5 Lbs Bonderite 710/gallon water

APPENDIX (Continued)

8. Bonderite 710 - (Continued)

B. Procedure for Application

1. Solvent clean aluminum alloy panels - MEK
2. Alkaline clean - Oakite #61A - 10 minutes
3. Rinse water
4. Chemically clean - Oakite #34 - 5-10 minutes
5. Rinse water
6. Bonderite 710 - 3 minutes
7. Cold water rinse
8. Rinse with hot water slightly yellow with Bonderite 710
9. Oven dry 125°F 10-15 minutes

9. Oakite "ChromaCoat"

A. Solution - 3 oz Oakite ChromaCoat/gallon water
Add 9 ml Nitric Acid/gallon water pH - 1.6

B. Procedure for Application

1. Solvent clean aluminum alloy panels - MEK
2. Alkaline clean - Oakite #61A - 10 minutes
3. Rinse water
4. Chemical clean - Oakite #34 - 5-10 minutes
5. Rinse water
6. Oakite "ChromaCoat" - (room temp.) 3 minutes
7. Rinse water
8. Oven dry - 125°F 10-15 minutes

10. Alodine 1200

A. Solution - 1.0 oz/gallon water

B. Procedure for Application

1. Solvent clean aluminum alloy panels - MEK
2. Alkaline clean - Oakite #61A - 10 minutes
3. Rinse water
4. Chemically clean - Oakite #34 - 5 - 10 minutes
5. Rinse water
6. Alodine 1200 - (room temp.) - 5 minutes
7. Water rinse
8. Oven dry - 125°F - 10-15 minutes

11. Anodize - This surface treatment was applied in Convair production per MPS 72.02D.